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# MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

2023-2024

YEAR 2

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## MECHANICAL ENGINEERING

## ADVANCED MANUFACTURING

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PROGRAMME SUPERVISOR(S):

Matthieu RAUCH



# YEAR 2 - Autumn Semester

## CORE COURSES

Course code	Title	ECTS Credits
ADMAN	Additive Manufacturing and Advanced Manufacturing Processes	5
CAXNC	Advanced CAD/CAM/CNC	5
CONF	Conferences	-
DOEXP	Design of Experiments Methods for Manufacturing	5
IDEPSS	Integrated Design Engineering of product service systems	4
MULTI	Multi-Physics Modeling for Processes	4
OPTIM	Optimization in Manufacturing Engineering	5

## LANGUAGE COURSES

Course code	Title	ECTS Credits
CCE3	Cultural and Communication English	2
ESP3	Spanish Language	2
FLE3	French Language	2

# YEAR 2 - Spring Semester

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## CORE COURSES

Course code	Title	ECTS Credits
THESIS	Master Thesis or Internship	30

# Master Programme - Mechanical Engineering - Advanced Manufacturing

YEAR 2 - Autumn Semester

## Additive Manufacturing and Advanced Manufacturing Processes [ADMAN]

*LEAD PROFESSOR(S): Jean-Yves HASCOËT*

### Objectives

At the end of the course the students will be able to:

- Understand the methods and tools to be implemented within the framework of Computer Aided Manufacturing with Numerical Control Machine-Tools
- Implement Design for Manufacturing approaches dedicated to Additive Manufacturing and other processes.
- Understand the challenges associated with Additive Manufacturing and other processes

### Course contents

This course covers:

- Evaluation of the industrial situation of Rapid Manufacturing Processes
- Definition of the setup of Additive Manufacturing and High-Speed Milling in a CadCam Context.
- Tutorials of manufacturing scenarios: Reception of the design specifications, Setup of the reverse engineering, Generation of the multi-axis trajectories, High Speed Machining on Parallel Kinematic Machine, Additive Manufacturing,

A combination of lecture and lab sessions will develop the tools and student skills

### Course material

- CADAM Theory and Practice, I. Zeid, Mc Graw-Hill
- Surface Modeling for CadCam, BK. Choi, Elsevier
- Fundamentals of Computer Integrated Manufacturing, A.L. Foston, CL Smith, T. Au, Prentice Hall
- NC Machine Programming and Software Design, CH Chang, MA Melkanoff, Prentice Hall
- Lecture and tutorial notes

### Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	8 hrs	8 hrs	16 hrs	0 hrs	0 hrs

# Master Programme - Mechanical Engineering - Advanced Manufacturing

YEAR 2 - Autumn Semester

## Advanced CAD/CAM/CNC [CAXNC]

*LEAD PROFESSOR(S): Jean-Yves HASCOËT*

### Objectives

At the end of the course the students will be able to:

- Create, manipulate and organise the numerical model of industrial products
- Understand, control and optimize the links in the manufacturing numerical data chain
- Design solid and surface components using complex CAD functions

### Course contents

This course covers:

- Curves and surfaces for component design
- Management of new product development - Product methods and development tools
- Knowledge Engineering, capitalise on know-how - Advanced CAD/CAM systems
- Data management
- Product data management, PDM Integration
- Product structure management
- Databases, DBMS - Product data exchanges.

A combination of lecture and lab sessions will develop the tools and student skills

### Course material

- CADAM Theory and Practice, I. Zeid, Mc Graw-Hill
- Surface Modeling for Cad/Cam, BK. Choi, Elsevier
- Fundamentals of Computer Integrated Manufacturing, A.L. Foston, CL Smith, T. Au, Prentice Hall
- NC Machine Programming and Software Design, CH Chang, MA Melkanoff, Prentice Hall
- Lecture and tutorial notes

### Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	12 hrs	0 hrs	20 hrs	0 hrs	0 hrs

# Master Programme - Mechanical Engineering - Advanced Manufacturing

YEAR 2 - Autumn Semester

## Conferences [CONF]

*LEAD PROFESSOR(S): Matthieu RAUCH*

### Objectives

This course is devoted to general conferences that may be given during the year.

### Course contents

### Course material

### Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	-	12 hrs	0 hrs	0 hrs	0 hrs	0 hrs

## Master Programme - Mechanical Engineering - Advanced Manufacturing

YEAR 2 - Autumn Semester

# Design of Experiments Methods for Manufacturing [DOEXP]

*LEAD PROFESSOR(S): Jean-François PETIOT*

### Objectives

At the end of the course the students will be able to:

- Define suitable Design of Experiments (DOE) for the identification of systems or processes
- Interpret the results of a DOE
- Analyze the results of experiments with statistics and data modeling tools (Analysis of Variance)
- Optimize the systems or processes according to design variables

### Course contents

This course covers:

- Introduction: Screening and Response Surface Modelling
- Full factorial designs 2k
  - o Effects graphs – interactions
- Fractional factorial designs
  - o Fractional 2k-p (alias theory – interpretation – orthogonality)
  - o Plackett-Burman DOE
  - o Taguchi tables
  - o Order of experiments - blocking
- Statistics for DOE
  - o Multiple linear regression and analysis of variance (ANOVA)
  - o Data modelling (cross validation, prediction error)
- DOE for Response surface modelling
  - o Optimal designs (D-optimal) – exchange algorithm
  - o Optimization (desirability – simplex algorithm)
  - o Case of Computer experiments (Latin Hypercube Sampling)
- The robust design TAGUCHI approach
  
- 3 tutorials (4h) with various exercises on Excel, MODDE, and Matlab software
- Project (8h) on the optimization of a system

### Course material

- Gilles & Marie-Christine SADO. Les plans d'expérience. AFNOR Technique
- Jacques GOUPY, Lee Creighton. Introduction aux plans d'expériences. DUNOD
- Méthodologie Expérimentale. Baléo, Bourges, Courcoux, Faur-Brasquet, Le Cloirec. Editions TEC &DOC
- Dreesbeke J-J, Fine J., Saporta G. Plans d'expériences. Applications à l'entreprise. Editions TECHNIP.
- Jacques GOUPY, Plans d'expériences pour surfaces de réponse. DUNOD
- Maurice PILLET. Introduction aux plans d'expériences par la méthode TAGUCHI. EO.Sup
- Anthony JIJU: Design of experiments for engineers and Scientists. 1st edition, Elsevier 2003

### Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	12 hrs	0 hrs	12 hrs	8 hrs	0 hrs



## Integrated Design Engineering of product service systems [IDEPSS]

LEAD PROFESSOR(S): Farouk BELKADI

### Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Understand the main concepts behind the paradigms of integrated product service systems.
- Understand the principles of system engineering, main processes and standards
- Conduct requirement collection and traceability
- Conduct Model Based System Engineering approach with SysML
- Have an insight into multi-physics simulation within system engineering perspective

This course contributes to the Sustainable Development Goal 9 "Industry, Innovation, and infrastructure" by increasing the innovative capacities of the students and helping them to apply formal design methodology.

### Course contents

These introductory lectures aim to present the main methods and tools of System Engineering as used in industry for the development of new complex systems. To do so, a first step consists in the introduction of the main foundations of system engineering, summarizing its main processes and presenting the potential organizations working on the SE standards. After this introduction, SysML language is explored to illustrate how this modelling tool is used along the SE process. Concretely, the following items will be detailed:

- Rapid introduction to complexity and new business paradigms of product service systems
- Introduction to the concept of system and system of systems
  - o What is a system? What is a system of system?
  - o System analysis foundations with the concept of facet:
    - Core features; system lifecycle; business models and system decomposition
    - The design process and the concept of facet
- System Engineering (SE)
  - o Definition of system engineering
    - Definitions from the standards
    - Main characteristics of SE
  - o Overview of main SE processes
    - Processes from the standards
    - Key System Engineering methods (V-model, Waterfall, incremental, etc.)
  - o Requirement management and functional analysis
    - The concept of requirement?
    - The requirement engineering and management process
    - From the requirement engineering to functional analysis
  - o Design of system architectures:
    - Concepts of functional (logical) and physical architectures.
    - Function allocation and design matrix
    - Modular architectures and Interface management
    - The RFLP approach
- System design and analysis with SysML language
  - o Main concepts of SysML
  - o Requirements management: Requirement diagram, Use Case diagram,
  - o Behavior analysis: Sequence diagram, State-Transition diagram, activity diagram
  - o Structure definition: Bloc definition diagram, Internal bloc diagram
  - o Connection between diagrams within a MBSE perspective
- Deploying a Model Based System Engineering (MBSE) approach

- o What is MBSE?
- o Practice and mini project on Eclipse Papyrus software
- Introduction to multi-physics simulation with open-modelica tool
- Overview of research work on system engineering

Exercises and homework will help student to apply the learned modelling languages in several case studies. A presentation from an industrial partner is planned to discover current industrial practices. A mini-project is also planned as a collaborative development project of information system dealing with real industrial use cases.

## Course material

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## Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	16 hrs	14 hrs	0 hrs	0 hrs	2 hrs

# Master Programme - Mechanical Engineering - Advanced Manufacturing

YEAR 2 - Autumn Semester

## Multi-Physics Modeling for Processes [MULTI]

LEAD PROFESSOR(S): Guillaume RACINEUX

### Objectives

At the end of the course the students will be able to:

- Read and explain scientific articles or bibliography related to multi-physics modeling of processes
- Identify the formulation of proper modelling including domain, physics, boundary conditions, constitutive equations and assumptions
- Generate appropriate modelling for a given process and question to answer

### Course contents

This course covers:

- Mathematical background (vectors, tensors and partial differential equations)
- Governing equations (conservations and principles, elasticity, fluid mechanics, electro-magnetism, plasticity, heat transfer etc)
- Constitutive equations (identification)
- Existence and unicity of solutions
- Resolution of problems (exact solutions, analytical approximates, numerical approaches)
- Multi-physics coupling

A combination of lectures, homework and lab sessions will develop the tools and student skills.

### Course material

- Process Modeling in Composites Manufacturing, Second Edition, 2010 by CRC Press, 630 Pages, Suresh G. Advani, E. Murat Sozer
- P. Boisse, Composite Reinforcements for optimum performance, 2011
- Friedrich Klaus, Fakirov Stoyko, & Zhang Zhong. (2005). Polymer Composites: From Nano- to Macro-Scale. Boston, MA: Springer Science+Business Media, Inc

### Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	16 hrs	16 hrs	0 hrs	0 hrs	0 hrs

# Master Programme - Mechanical Engineering - Advanced Manufacturing

YEAR 2 - Autumn Semester

## Optimization in Manufacturing Engineering [OPTIM]

LEAD PROFESSOR(S): Fouad BENNIS / Matthieu RAUCH

### Objectives

The lectures present different theoretical and computational aspects of a wide range of optimization methods for solving a variety of problems in mechanical engineering. The main objective of this course is to give the students the ability to formalise, select the appropriate method, implement the optimisation problem and then analyse the results in order to take the best decision regarding the objectives, variables and the constraints

### Course contents

This course covers:

- Basic concepts of optimization,
- Gradient based methods,
- Evolutionary algorithms,
- Multi objective optimization methods,
- Robust optimization methods,
- Multidisciplinary optimization problems,
- Programming aspects,

Practical Work: exercises and project work on the design optimisation of a mechanical product, manufacturing process or system.

The students will:

- understand different theoretical and computational aspects of a wide range of optimization methods,
- realize the possibilities offered by the different optimization methods,
- use optimization toolboxes.

### Course material

- R. Fletcher, Foundation of structural optimization.
- Melanie Mitchell, An Introduction to Genetic Algorithms

### Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	16 hrs	0 hrs	16 hrs	0 hrs	0 hrs

# Master Programme - Mechanical Engineering - Advanced Manufacturing

YEAR 2 - Autumn Semester

## Cultural and Communication English [CCE3]

*LEAD PROFESSOR(S): David TROYA*

### Objectives

Team-building and Communicational English:

- Understand the general concepts of team-building
- Build a team-building project
- Understand and nurture the creative process
- Enhance self-belief and self-empowerment

Behavioral skills in an inter-cultural environment:

- Strengthen self-confidence and capacity for interaction
- Develop active listening and reformulation skills
- Develop networking skills

### Course contents

Cultural and Communicational English: exercises to explore in practice the areas of culture and communication  
 Field-related or inter-cultural project.

### Course material

Written and televised press, information and digital tools, general documents business environment and company strategies.  
 Internet conferences (Ted Talks, etc.), our own educational materials on Hippocampus (Moodle).

### Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

# Master Programme - Mechanical Engineering - Advanced Manufacturing

YEAR 2 - Autumn Semester

## Spanish Language [ESP3]

LEAD PROFESSOR(S): Marta HERRERA

### Objectives

For beginners:

Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)

Acquisition of vocabulary and linguistic structures

Be able to talk about yourself and those around you

Be able to express oneself during daily activities

Know how to give your opinion

For advanced students:

Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)

Acquisition of specialised vocabulary

Be able to understand the essential content of concrete or abstract subjects including a technical discussion

Be able to communicate spontaneously and fluently

Be able to express oneself in a clear and detailed manner, to express an opinion on a topical subject

### Course contents

For beginners:

Personal environment (introduce yourself, express yourself, your tastes, your character, your hobbies, etc.), your surroundings (friends, family, location, climate), your interests (sports, leisure)

Present tense (regular and irregular)

Language patterns to express habit, obligation, "gustar" and its equivalents,

Possessive adjectives

Differences between "es", "está", "hay"

Use of "por" and "para"

Adverbs and frequency patterns

Numeral adjectives

For advanced students:

Knowledge of the Hispanic world (economic, technical, cultural and social environment)

Present tense (regular and irregular)

Imperative

Past tenses

Direct / indirect style

Future tense

Conditional tense

Present and past subjunctive moods

### Course material

Preparation manuals, our own tailor-made documents, written and internet press, general civilization documents, digital tools

### Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
Spanish	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

# Master Programme - Mechanical Engineering - Advanced Manufacturing

YEAR 2 - Autumn Semester

## French Language [FLE3]

*LEAD PROFESSOR(S): Silvia ERTL*

### Objectives

The objective is to familiarize the learner with the French language and French culture through an entertaining task-based communicative language teaching, focused on speaking combined with:

- Phonetics
- Self-correcting exercises on our learning platform
- Learning Lab activities
- Project work
- Tutoring

Course objectives include the acquisition and reinforcement of vocabulary, syntax, and pronunciation by both traditional means and through the use of digital resources. Students will learn general French, develop language skills of oral and written comprehension and expression.

After completing this course (32 hours + personal work), the students will be able to communicate in spoken and written French, in a simple, but clear manner, on familiar topics in the context of study, hobbies etc. Another important goal of this course is to introduce the student to French culture.

At the end of the course, complete beginners can achieve an A1 level and some aspects of the A2 of The Common European Framework of Reference for Languages. More advanced students may aim for B1/B2 levels. Those who already completed the first year of the French course will be prepared for working in a French business environment.

### Course contents

Two different tracks are proposed: track 1 for students newly arrived at Centrale Nantes and track 2 for students who have completed the first year of the French course. Track 1:

Full range of practical communication language exercises: reading comprehension, listening comprehension, written expression, oral expression.

Learners will be able to use the foreign language in a simple way for the following purposes:

1. Giving and obtaining factual information:

- personal information (e.g. name, address, place of origin, date of birth, education, occupation)
- non-personal information (e.g. about places and how to get there, time of day, various facilities and services, rules and regulations, opening hours, where and what to eat, etc.)

2. Establishing and maintaining social and professional contacts, particularly:

- meeting people and making acquaintances
- extending invitations and reacting to being invited
- proposing/arranging a course of action
- exchanging information, views, feelings, wishes, concerning matters of common interest, particularly those relating to personal life and circumstances, living conditions and environment, educational/occupational activities and interests, leisure activities and social life

3. Carrying out certain transactions:

- making arrangements (planning, tickets, reservations, etc.) for travel, accommodation, appointments, leisure activities
- making purchases
- ordering food and drink



### Track 2:

This track follows on directly from the first-year French course, developing and completing the concepts studied thus far. The main themes are: housing, health and work. These topics will help prepare students for their future work environment. For example, housing is explored in the form of a search for accommodation upon arrival in a new city. Special workshops for CVs and cover letters, elevator pitches and job interviews.

### Course material

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Preparation manuals, our own tailor-made documents, written and televised press, internet, general civilization documents, digital tools, our own educational materials on Hippocampus (Moodle).

### Assessment

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Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

# Master Programme - Mechanical Engineering - Advanced Manufacturing

YEAR 2 - Spring Semester

## Master Thesis or Internship [THESIS]

LEAD PROFESSOR(S): *Matthieu RAUCH*

### Objectives

- Be exposed to and adapt to an industrial or research environment
- Put in practice the scientific and technical skills acquired in the previous semesters
- Strengthen interpersonal and communication skills
- Be part of or manage a project
- Organize tasks, analyze results and build deliverables

### Course contents

Students should be pro-active and career-oriented in the search for their thesis/internship. The topics are approved by the program supervisor to ensure an adequate Master level. The thesis/internship is evaluated through the submission of a written report and an oral defense.

### Course material

- Turabian Kate Larimore, Booth Wayne Clayton, Colomb Gregory G., Williams Joseph M., & University of Chicago press. (2013). A manual for writers of research papers, theses, and dissertations: Chicago style for students and researchers (8th edition.). Chicago (Ill.) London: University of Chicago Press.
- Bui Yvonne N. How to Write a Master's Thesis. 2nd ed. Thousand Oaks, Calif: Sage, 2014.
- Evans David G., Gruba Paul, et Zobel Justin. How to Write a Better Thesis. 3rd edition. Carlton South, Vic: Melbourne University Press, 2011.

### Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	30	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs